J-UCAS Common Systems & Technologies Industry Day For Common Operating System (COS) Development

Mr. Marc J. Pitarys
Deputy Directo
Joint Unmanned Combat Air System
June 24, 200

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Topics

- J-UCAS Overview
- The Common Operating System (COS)
- The COS Consortium
- Technology Contributor Opportunities

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Joint Unmanned Combat Air Systems --

Unique Joint Program

- **DARPA-Air Force-Navy Development – Began 1 Oct 2003**
  - **Outgrowth of Earlier DARPA Programs**
- **Program Objectives**
  - **Demonstrate Concept Feasibility & Flexibility**
  - **Conduct Operational Assessment (OA) of J-UCAS Capabilities**
  - **Maintain Competitive Environment throughout the Program**
  - **Facilitate Early Fielding Decision … End of the Decade**
- **Atypical Program Architecture**
  - **Spiral Development Approach with Aggressive Timelines**
    - **Cutting Edge Technology … ATDs … Operational Assessment**
  - **Contractors**
    - **Boeing Team (X-45 air vehicles)**
    - **Northrop Grumman Team (X-47 air vehicles)**
    - ***Common Operating System* Consortium (Boeing, NG, Johns Hopkins APL)**
- **Large Program - $4B+ over the FYDP**

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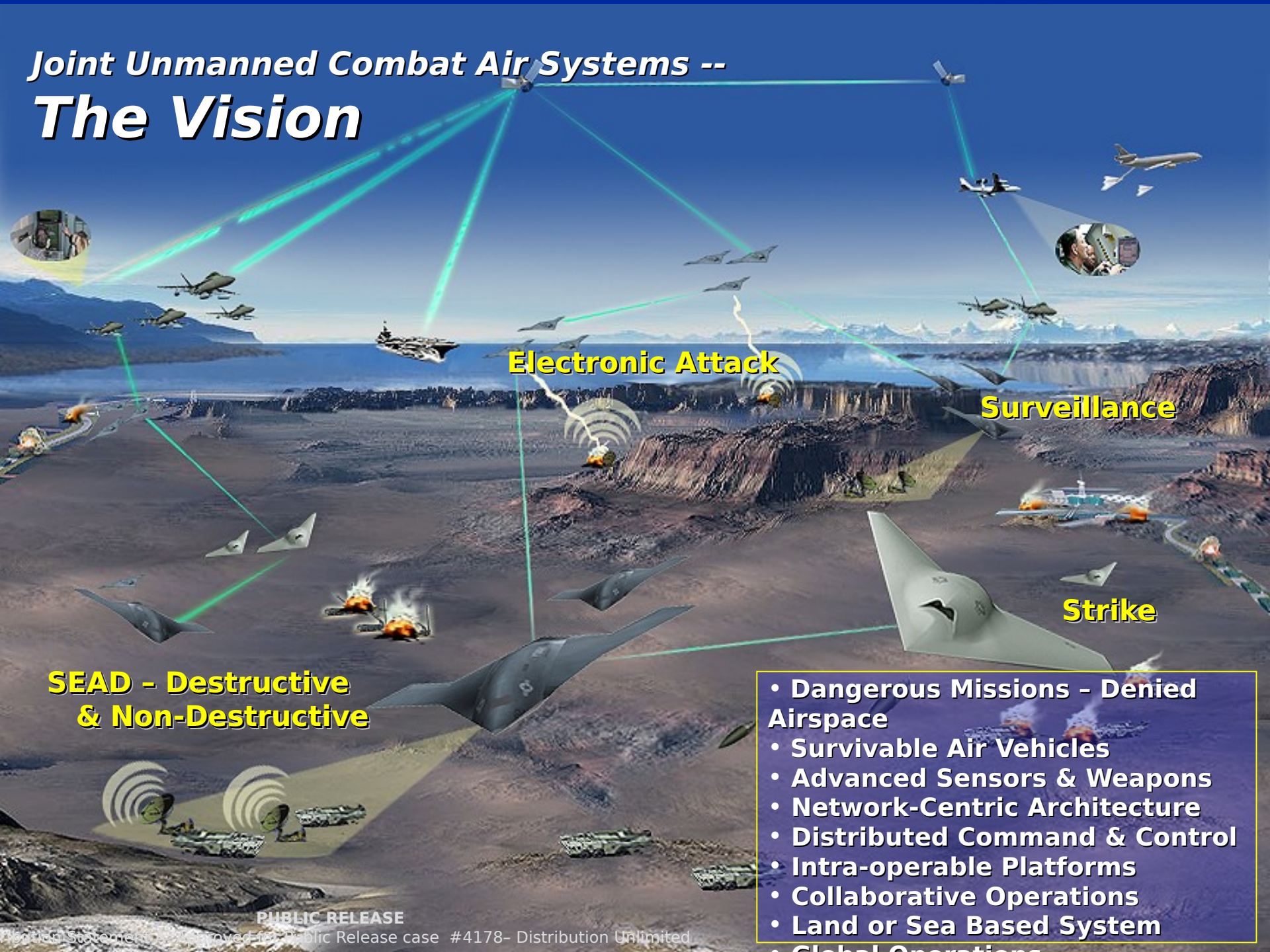

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J-UCAS System Elements

A Way Forward ...

J-UCAS

Operational Infrastructure

Air Vehicles

Communications

Control Stations

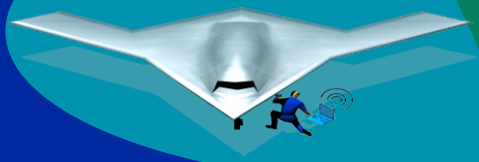
Common Operating System

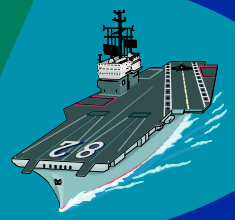
Architecture, algorithms & software:

- Control / manage system resources
- Facilitate information exchange
- Provide battlespace awareness
- Enable inter-platform functionality
- Enable autonomous operations
- Maintain quality of service

Payload Systems

Direct Support





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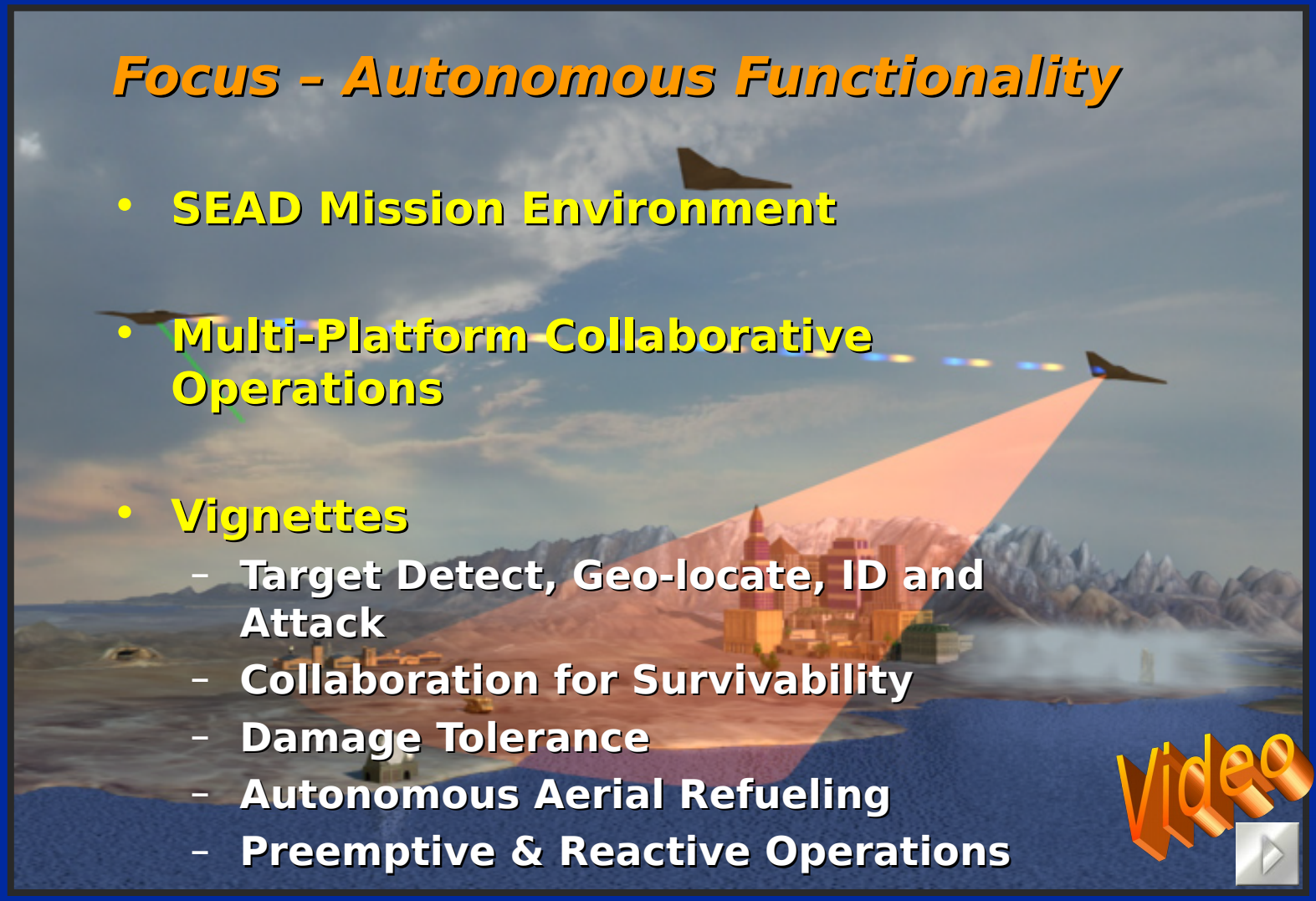
Video Animation (Excerpt) --

J-UCAS in Action



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Joint Unmanned Combat Air Systems -- … 'Raising the Bar'

J-UCAS

Operator / Vehicle Ratio

Predator	Global Hawk	J-UCAS
Many : 1	1 : 1	1 : Many

Operational Environment

Predator & Global Hawk
- Secured Airspace
- Land Based
- Dissimilar Air Ops

J-UCAS
- Denied Airspace
- Survivable Design
- Land & Sea Based
- Mainstream Air Ops

Mission Planning Time

Global Hawk
- Single Ship
- Days

J-UCAS
- Multi Ship
- Hours

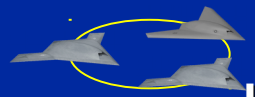
Communication Management

Global Hawk
- Dedicated Channel per Vehicle
- Large Bandwidth Blocks

J-UCAS
- Shared Channels
- Quality of Service
- Net Ready

Cooperative Operations

Fielded Systems
- Single Ship Only
- Stove-Piped Systems
- No Cooperation



J-UCAS
- Multi Ship, Cooperative Targeting & Attack
- Interoperable

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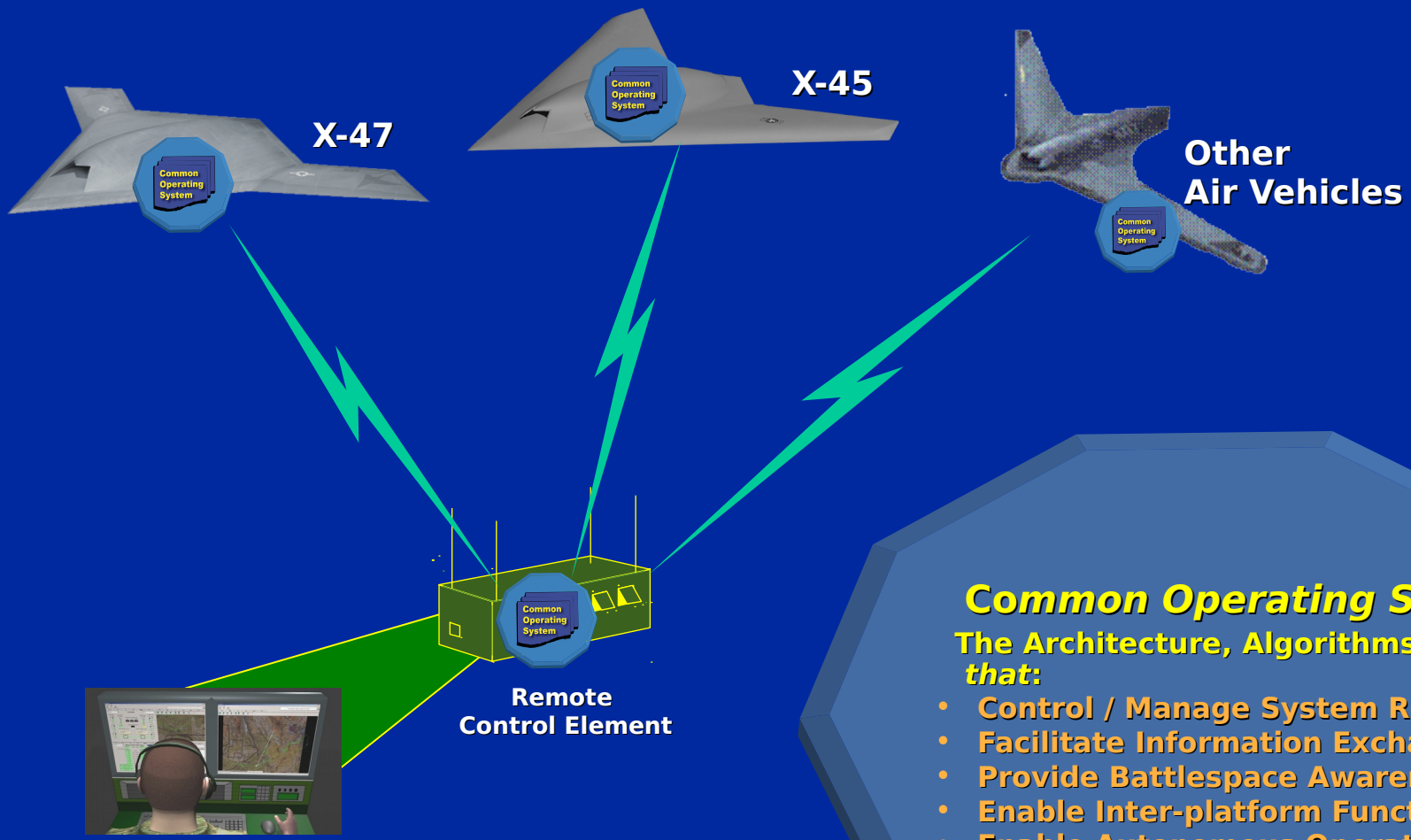
Common Operating System



Common Operating System

The Architecture, Algorithms & Software, *that*:

- Control / Manage System Resources
- Facilitate Information Exchange
- Provide Battlespace Awareness
- Enable Inter-platform Functionality
- Enable Autonomous Operations
- Maintain Quality Of Service

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J-UCAS "Common Operating System"

J-UCAS Common Operating System	Commercial Operating System
Manages Resources: –Sensors –Weapons –Communication Links / Bandwidth –Air Vehicles	**Manages Resources:** – Memory – CPU time – Disk Space – Peripheral Devices (keyboard, mouse, Etc.)
Provides Security: –Controls Access to the System	**Provides Security:** –Controls Access to the System
Facilitates Information Exchange: – Global Information Grid (GIG)	**Facilitates Information Exchange:** – Data Bus
Human System Integration (HSI): – Decision Aids – Common relevant operational picture	**Graphical User Interface (GUI):** – Windows System organizes images and controls on screen
Provides System Services: – Contingency Management – Fusion – Publish/Subscribe – Discovery/Mediation – Communication Services – Data Repository	**Provides Services:** – Schedules, loads, initiates, and supervises the execution of programs – Allocates storage – initiates and controls input/output operations – Handles errors
Resides: – On top of Embedded OS	**Resides:** – On top of BIOS

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Common Operating System (COS) --

Why Develop It?

- **Provide Needed Mission Functionality**
  - Manages interactions between system components
    - Enable collaborative operations
  - Allows Autonomous Operations
  - Facilitate agile bandwidth management
- **Reduce Development Costs**
  - Build it one time
  - Don't "throw it away"- Use on Follow-on Programs
- **Reduce Technology Barriers to Entry**
  - Attract 'best-of-breed' algorithms & functionality
  - Enable competition at the function level
- **Assure Intra- and Inter-operability**
  - Primes collaborate to develop
  - Same software used on all platforms
- **Decouple System IT from Platforms**
  - Allow natural development timelines
  - Reduce interdependencies

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Common Operating System -- Functionality Lines of Demarcation

J-UCAS

Common Operating System

- Information Management
  - Publish/Subscribe
  - Fusion
- Battle Management
  - Common Relevant Operational Picture
  - Integrated Fire Control
- Human System Integration
  - Display Management
  - Decision Aids
  - Situation Awareness
- Planning
  - Mission
  - Collection
  - Dynamic Re-planning
- Resource Management
  - Sensors
  - Payloads
  - Attack
  - Power
- Contingency Management
  - System
  - Mission
- Network Management
  - Quality of Service
  - Bandwidth Allocation
  - Link Control
- Critical GIG Interfaces
  - MILSTAR
  - Link 16
  - SIPRNET
  - TCDL
  - JWICS

Sensors

- Signal Processing
- Mission Data Processing
- Sensor Modes

Support

- Vehicle Specific Health Management
- Ground Test
- Built in Test
- Portable Field Testers

VMS

Guidance
Flight Control
Vehicle Contingency Management
Fuel Control
Engine Control
Diagnostics
Redundancy Management
Subsystem Control
GPS/INS Navigation
IFF Transponder
Brakes
Environmental Control System

- Landing Gear Actuators
- Power Distribution Units
- Weapons Bay Doors
- (Taxi, take-off, and landing capability)

Weapons

- Stores Management
- Crypto Key Loading

Platform Specific Software

- Real Time Operating System (RTOS)
- Operating System Isolation Layer
- Subsystem interfaces
- Taxi and take-off operator displays

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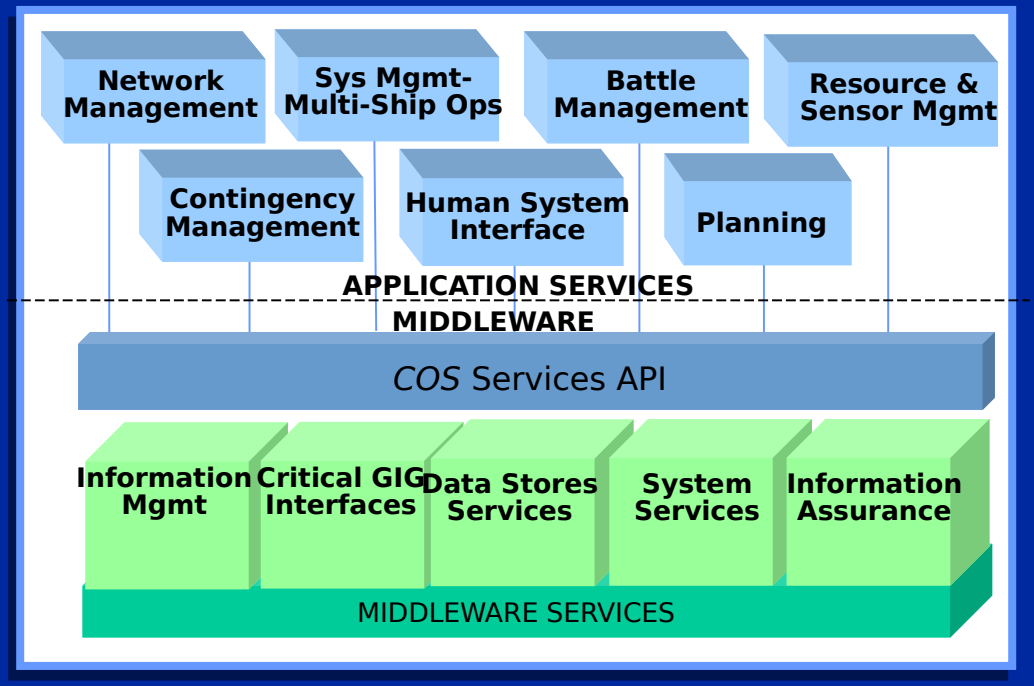
Common Operating System -- Architecture

Architecture Characteristics

- **Open**
  - Specifications available to multiple contractors
- **Non-Proprietary**
  - Source Code Available
  - Can be used, copied, modified, and redistributed by the Government without charge
- **Uses Industry Standards**
  - Technical Standards agreed to by Industry and Professional Organizations



Government Rights to Application Services (Prioritized)

1. **Government Purpose Rights**
2. **License software from various developers for the life of the *COS***
3. **Limited Rights where there is no alternative *(in rare instances)***

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Common Operating System Build Schedule

(As of 31 May 05)

J-UCAS

- (Middleware Services)
  - Publish/Subscribe
  - Discovery/Mediation
  - Communication Services
  - Data Repository
- OS Abstraction Layer
- Demonstration Application Services
  - Weapon-Target Assignment
  - Sensor Manager
- Human System Interface (HSI) for Demo missions
- Distributed Interactive Simulation (DIS) interface

Build 0: Basic Services

Dec 05

- Functionality from Build 0
- Critical GIG interfaces
  - BLOS communications
  - LOS communications
- JMPS Pre-mission planning support
  - Primary Route and Contingency Management
  - Support for Comm, Single Ship ESM, and Weapons
- HSI for Single Ship Demos
- Sensor Management
  - SAR- Limited to Image Collection and BIT
  - ESM- Single Ship (ALR-69)
- Weapon Management
- Information Management: Fusion (ESM Track Data)

Build 1: Single Ship

Jun 07

Dec 08

Build 2: Multi-Ship

- Functionality from Build 1
- Interfaces to Mission Planning and Intel Cell
  - SIPRNet
  - JWICS
- In-flight Mission Planning
  - Primary Route Planning and Contingency Management
  - Auto-router
- HSI for Multi-Ship Operations
- Sensor Management
  - ESM- Multi-Ship
  - SAR- Automatic Target Cueing, Image Registration, and Fusion
- Battle Management*: Interface to ADSI
  - Collects Track Data for operators
- Network Management*
  - Quality of Service
- Attack Management
- Contingency Management
  - System
  - Mission
- Information Management: Fusion (Off-board/On-board)

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COS Functionality Description- Build 0

J-UCAS

BUILD 0	
Middleware Services	All tasks associated with the development of core services that enable an application to interoperate within the enterprise
•*Publish/Subscribe*	This component provides services to support synchronous and asynchronous exchanges. This includes publication/subscription, messaging services, etc.
•*Discovery/Mediation*	The discovery component provides a set of services that enables the formulation and execution of search activities to locate data assets (files, databases, directories, web pages, streams) by exploitation metadata descriptions stored in and or generated by Information Technology (IT) repositories (directories, registries, catalogs, etc). This also includes the ability to search for metadata semantics to support mediation. This mediation component provides a set of services that enable transformation processing (adaptation, aggregation, transformation, and orchestration), situational awareness support (correlation and fusion), negotiation (brokering, trading, and auctioning services), and publishing.
•*Communication Services*	This component provides application level services that provide point to point, client/server, peer to peer, multicast, and other connection topologies. These would be low-level protocol connections, as opposed to a publish/subscribe service that hides the protocol connection.
•*Data Repository*	All of the mechanisms for managing files, databases, and other sources of persistent storage. Data may be cached locally to improve performance, as well as stored in a central repository. Distributed data storage shall not be addressed.
OS Abstraction Layer	This component provides programming interfaces to a common Portable Operating System Interface (POSIX) compliant set of operating system abstractions.
Demonstration Application Services	Applications built to demonstrate capabilities of the Build 0 middleware.
•*Weapon-Target Assignment*	All tasks associated with the component development which provides weapon target pairing services based on mission type, air vehicle type and weapon type.
•*Sensor Manager*	Sensor Manager for demonstration purposes.
Human System Interface for Demo Missions	Displays created for visibility into of middleware services activities.
Distributed Interactive Simulation (DIS) Interface	A modeling and simulation protocol that allows the Government and Contractor simulation sites to pass data and control interface in data packets using a common description.

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COS Functionality Description- Build 1

J-UCAS

BUILD 1	
Critical GIG Interfaces	
BLOS Comm	Communication Interfaces to the individual systems' primary and backup Beyond Line of Sight (BLOS) communication terminals. A common set of commands for command and control of the air vehicles and their subsystems.
LOS Comm	Communication Interfaces to the individual systems' primary and backup Line of Sight (LOS) communication terminals. A common set of commands for command and control of the air vehicles and their subsystems.
JMPS Pre-mission planning support	Functions associated with the mission/route plan generated by the mission planning cell. Converting the mission/route plan and for use with the Common Operating System.
•Primary route and Contingency Management	Primary route and contingency (back up) route planned before vehicle take-off.
•Support for Comm, Single Ship ESM, and Weapons	Pre-mission mission/route planning (interface to the Joint Mission Planning Segment (JMPS) or Mission Planning Cell to provide routes, communications, weapons, sensors, and other task plans)
HSI for Single Ship Demos	The HSI includes but is not limited to: • Health and Status Management • Decision Aids • Platform Specific Operator Interfaces
Sensor Management	Sensor Management component services that include support for: • Electronic Support Measures (ESM) • Synthetic Aperture Radar (SAR)
•SAR- Limited to Image Collection and BIT	The SAR sensor management component provides the capability to send a message to operate and receive status on the SAR system and antenna. The SAR sensor management component shall provide the capability to: • Switch on/off the SAR sensor including emergency switch off and place the sensor in standby or ECM/ECCM mode operation. • Receive status on the SAR systems.
•ESM- Single Ship ALR-69	The ESM sensor management product provides the capability to send a message to operate, and receive status on the ESM sensor. The ESM sensor management component shall provide the capability to: • Switch on/off the ESM sensor including emergency switch off and place the sensor in standby or Electronic Countermeasures/Electronic Counter-Countermeasures (ECM/ECCM) mode operation. • Receive status on ESM systems.
Weapon Management	All tasks associated with the component development which provides the capability to determine the launch acceptability region for an air vehicle based on weapon type, target parameters, environmental conditions, and air vehicle position and velocity.
Information Mangement Fusion (ESM Track Data)	Track fusion provides the management of track responsibility between systems to include handover and synchronization. Fuse Electronic Order of Battle (EOB) data with ESM data

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COS Functionality Description- Build 2

BUILD 2 (Pg 1 of 2)	
Interfaces to Mission Planning and Intel Cell	
•*SIPRNet*	Interface software that allows J-UCAS to communicate over the Secret Internet Protocol Routing Network (SIPRNet).
•*JWICS*	Interface software that allows J-UCAS to the Joint Worldwide Intelligence Communication System (JWICS).
In-flight Mission Planning	This includes the management of functions which determine when new plans should be generated or considered by the operator and/or the intelligent software when running autonomously. Mission planning component services shall support: • Threat Assessment • Target Assessment • Mission/Route Assessment • Vehicle Assessment • Prediction Models
•*Primary Route Planning and Contingency Management*	In-flight route generation for primary route and other contingency route options. All tasks associated with the component development of route survivability.
•*Auto-router*	The Auto-Router component generates routes which account for the current set of tasks, communications status, sensor status, threat environment, natural environment (i.e. weather), terrain, and signature for an air vehicle. Its primary task is to generate survivable routes for the Air Vehicle in real-time. Route survivability determines how survivable a route is given a threat environment and signature for an air vehicle. Route Survivability is defined to be the capability to produce a Probability of Survival (P(s)) of an air vehicle flying a given route.
HSI for Multi-Ship Operations	The Human System Interface (HSI) includes that allows operators to control up to four air vehicles during mission operations.
Sensor Management	Sensor Management component services shall include support for ESM in the form of the Advanced Tactical Targeting Technology (AT3) and SAR collections to support the kill chain.
•*ESM- Multi-Ship*	The ESM – Multi-ship sensor management component shall provide the capability to operate, control, and receive status in the Multi-ship ESM sensor (AT3)
•*SAR- Automatic Target Cueing, Image Registration, and Fusion*	The software necessary to chip images out of SAR maps, register the pixels from the SAR map for generating Desired Mean Points of Impact for Precision Guided Munitions, and Fusion of SAR imaged targets with targets obtain from the Electronic Order of Battle (EOB).

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COS Functionality Description- Build 2 (cont.)

BUILD 2 (Pg 2 of 2)	
Battle Management: Common Relevant Op. Picture	The functions necessary to provide situation awareness to J-UCAS operators and mission commanders. Display of blue and red force information. Interface to Air Defense Systems Integrator (ADSI)
Network Management- Quality of Service	Services that provide an application/transport layer end-to-end quality of service. Quality of Service is the ability of a network to deliver service needed by specific network applications from end-to end with some level of control over delay, loss, jitter, and/or bandwidth.
Attack Management	All tasks associated with the development of Attack/Mission Management related components shall be allocated to the Mission Management IPT. This includes all functions which determine the specific assignment of resources against objectives. Mission Management component services shall support: • Task Allocation • Sensor Pairings • Weapon-Target Pairings • Pairing Algorithm Selector • Task generation
Contingency Management	This element includes all efforts necessary to design and develop the application level software for COS Contingency Management. Contingency Management is the detection of off-nominal system and mission conditions and suggested course of action (behavior) for the operator and/or intelligent software.
•*System*	System failures are defined as those failures pertinent to a system as defined by a single J-UCAS system (i.e. X-45 air vehicle, X-47 ground station, Mission Planning Cell).
•*Mission*	Mission failures are defined as those failures pertinent to a completing a mission (i.e. Persistent ISR, Pre-emptive destruction SEAD …).
Information Management: Fusion (Off-board/On-board)	Information Fusion component services for COS shall initially support: • Raw Data Processing • Automatic Target Recognition/Automatic Target Cueing • Correlation to support Target Identification using on-board and off-board INTEL products • Mensuration

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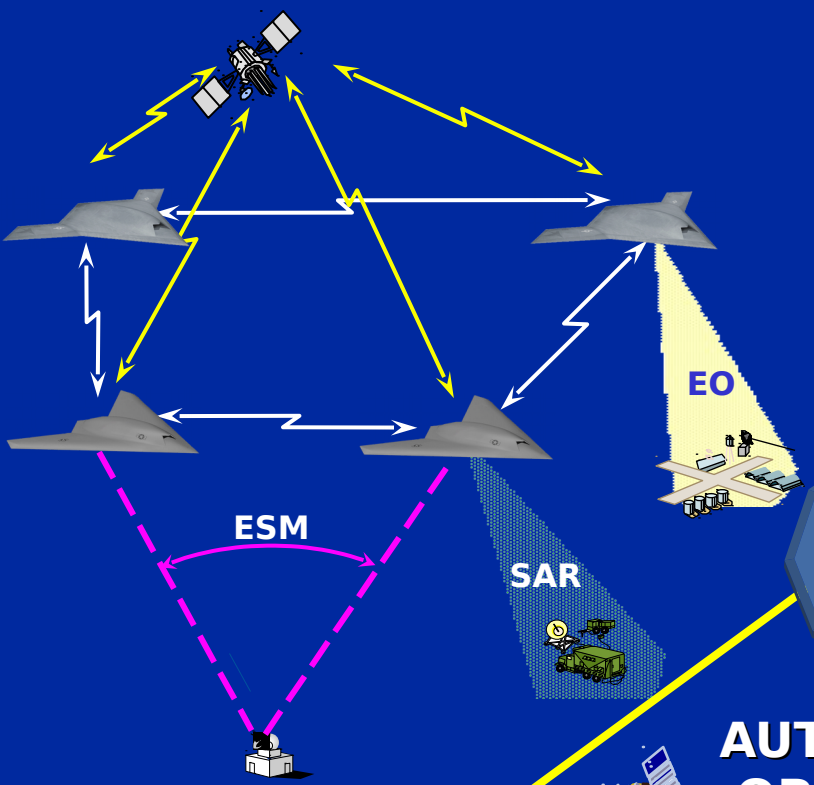
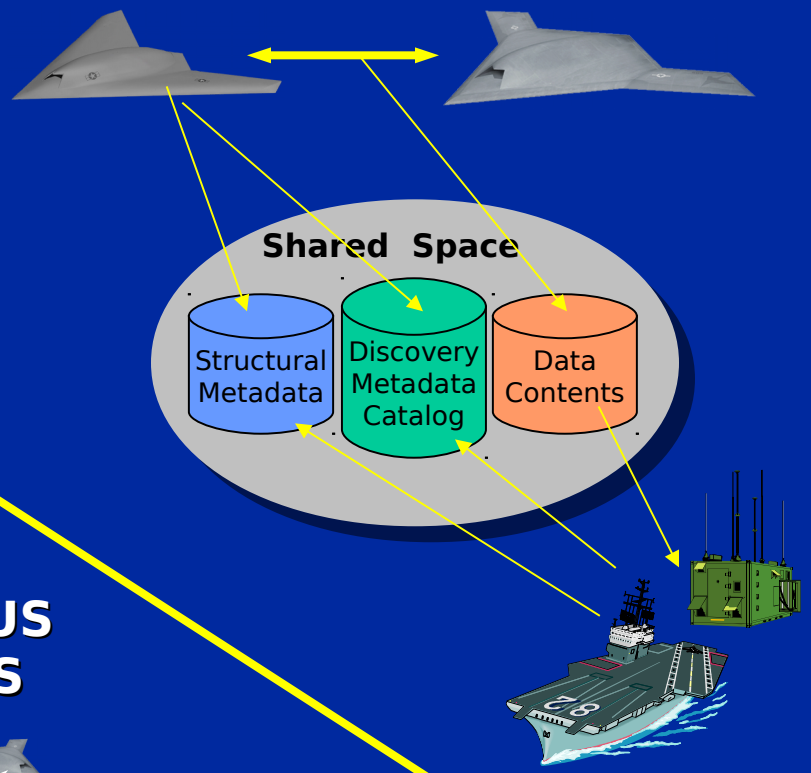
COS Supports J-UCAS Advanced Operations

MULTI-SHIP OPERATIONS

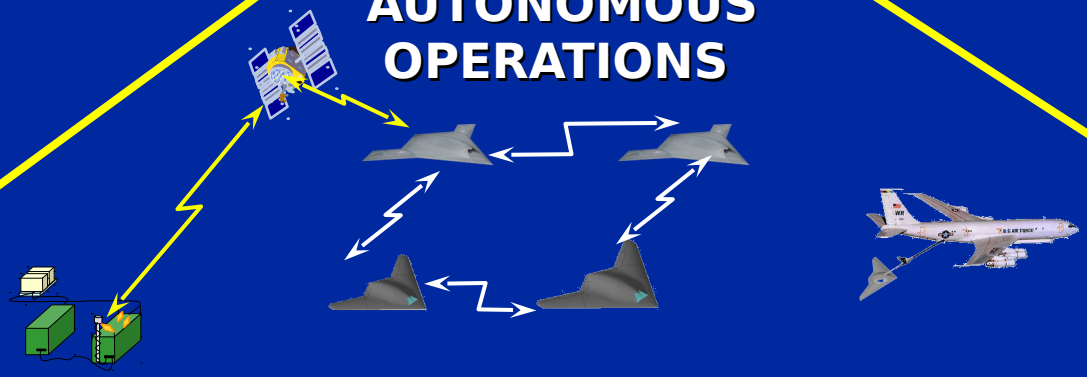


NETWORK-CENTRIC OPERATIONS



Common Operating System

AUTONOMOUS OPERATIONS



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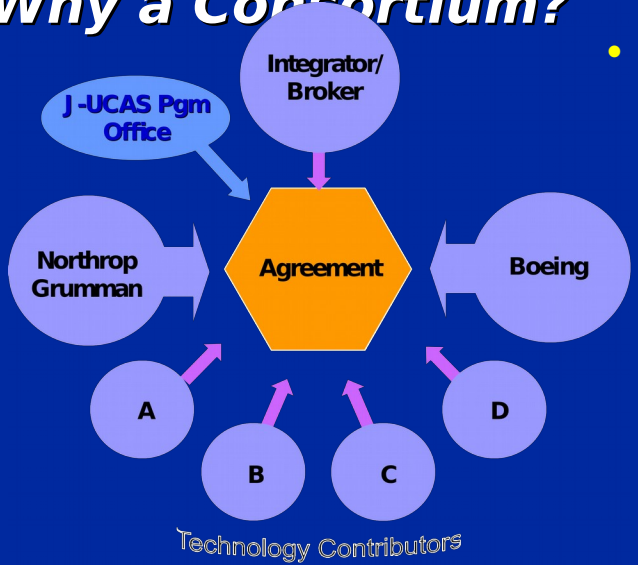
Development Strategy Rationale

Why a Consortium?



- **"Consortium" is a single entity composed of numerous organizations to focus resources on a common effort**
  - Common functionality is needed by both primes
  - No one company has all the needed resources nor capabilities to complete the *Common Operating System* development
  - Opportunity to incorporate the best of breed solution
  - Lowers barriers to entry for new technology
  - Avoids a proprietary, closed OS implementation

- **Provides a formal mechanism for cooperation amongst developing organizations**
  - Rules: Articles of Collaboration
  - Established Structure: Integrator/Broker and Primes
  - Process for dispute resolution
- **Allows the Government a mechanism to control ownership of the *Common Operating System***

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Integrator/Broker Description

- **Key 3rd Party … Not an LSI**
- **Intellectual Property Opportunity – None … Limited?**
- **Six objectives of Integrator Broker (described in solicitation)**
  1. **Act as an impartial broker within the consortium.**
  2. **Facilitate, coordinate, and (if necessary) complete the development of the J-UCAS enterprise architecture.**
  3. **Facilitate, coordinate, and (if necessary) complete the development and integration of the *COS*.**
  4. **Develop and maintain an executable J-UCAS architectural model.**
  5. **Provide available infrastructure to support technology identification and evaluation (e.g. simulation, labs, etc.).**
  6. **Maintain configuration control of Interface Control Documents (ICDs), executable models, and *COS* software releases.**

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COS Consortium --

Roles & Responsibilities

- **JHU/APL**
  1. Function as the Consortium's recording secretary and configuration manager for the COS development effort;
  2. Provide for an electronic, WEB-Based collaborative environment;
  3. Administer and coordinate technology competitions;
  4. Administer certain Technology Contributor subcontracts; and
  5. Remain free from conflicts of interest to fulfill its role as DARPA's trusted agent.

- **Boeing and NGSC**
  1. Participate as Primary Developers and Integrators of the COS

- **Technology Contributors**
  1. Contribute Technology to the Consortium as authorized by the CMC
  2. Not party to the Articles of Collaboration

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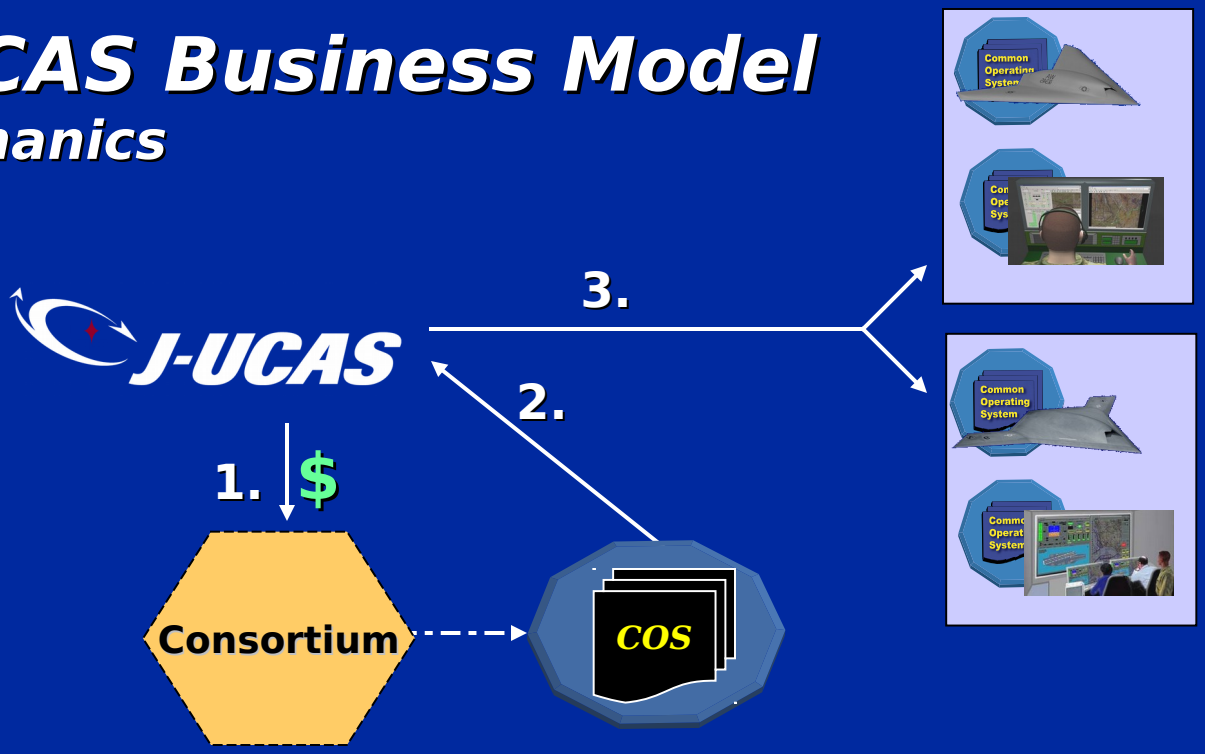
J-UCAS Business Model

Mechanics



- **Government funds *COS* development through the individual consortium members' agreements**
- **Consortium delivers *COS* software to the government- Integrator/Broker releases COS to the government**
- **Government furnishes *COS* to the primes for integration into their systems**

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Potential Organizations to work as a Technology Contributor

- **Federally Funded R&D Centers**
- **Military and Government Laboratories**
- **Universities**
- **DOD Contractors**
- **Others?**
- **Teams?**

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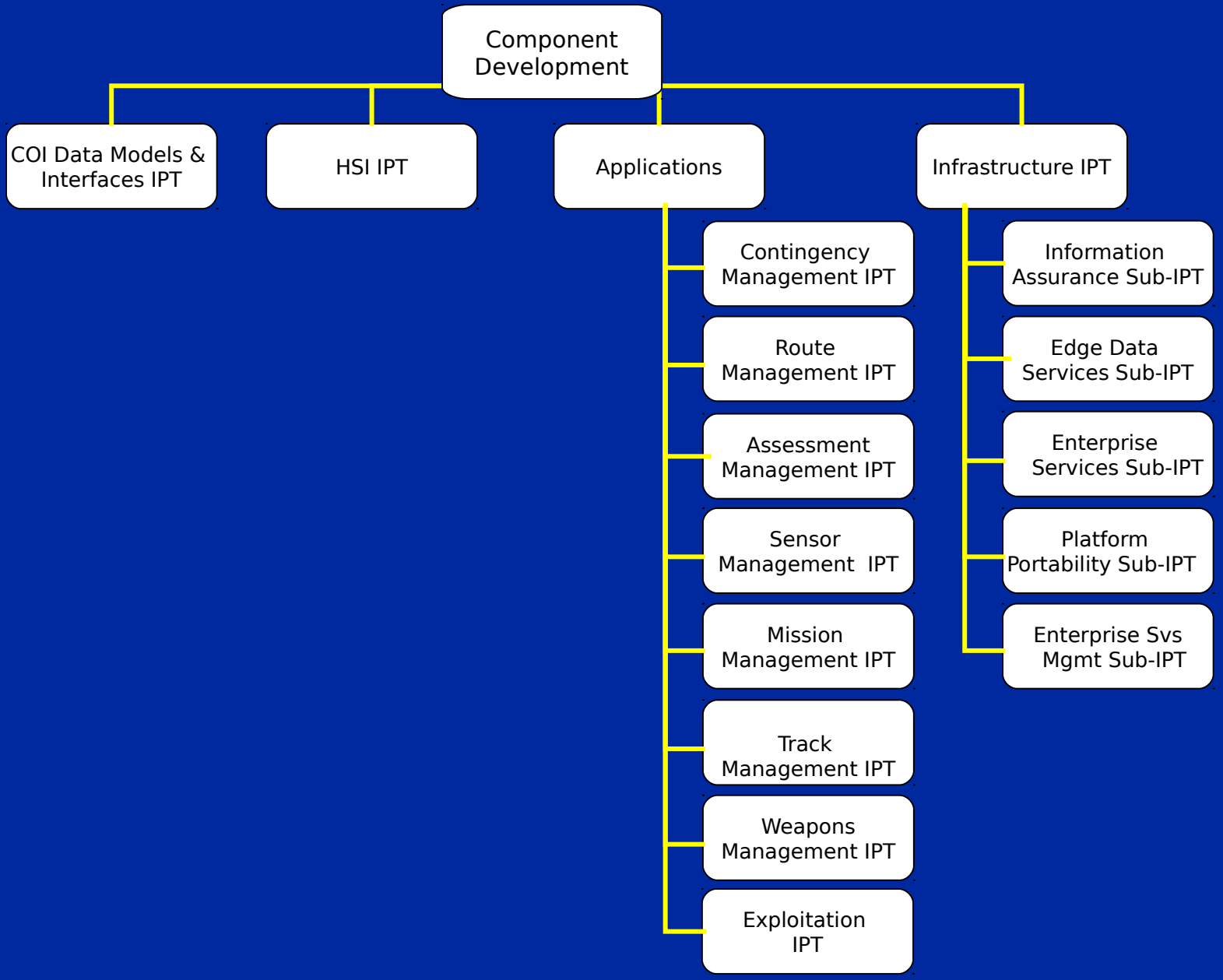
COS Applications & Infrastructure



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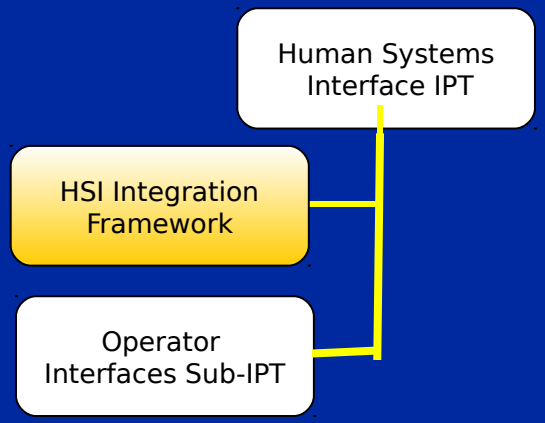
COS HSI (Detail)



TC Candidate Future

TC Candidate

J-UCAS has an Immediate Need for HSI Technology Contributor Support

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Government's Intent for COS HSI

- Consistent "look and feel" in terms of appearance and behavior
- Generic and Community of Interest (COI) functionality
- Utilization of services to provide necessary functionality
- Legacy tolerant approach
- Flexibility and scalability – ability to modify and evolve as new techniques and technologies mature
- User roles and profiles

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Situation Assessment

- **Three development efforts taking place**
  - **X-45 control element, X-47 control element, and *COS***
  - **Two vehicle specific control elements (X-45 and X-47) are being developed**
    - **Each prime developing a platform specific architectures, integrating vehicle and control element hardware, software, and operator interfaces with the *COS***
- **For the Operational Assessment, the Mission Control Element will need:**
  - **Platform-specific software for taxi, takeoff, launch, and recovery; health and status monitoring; vehicle contingency management**
  - ***COS* software for mission management**
- ***COS* provides mission management functionality common to both vehicles and integrates selected vehicle-specific functionality**

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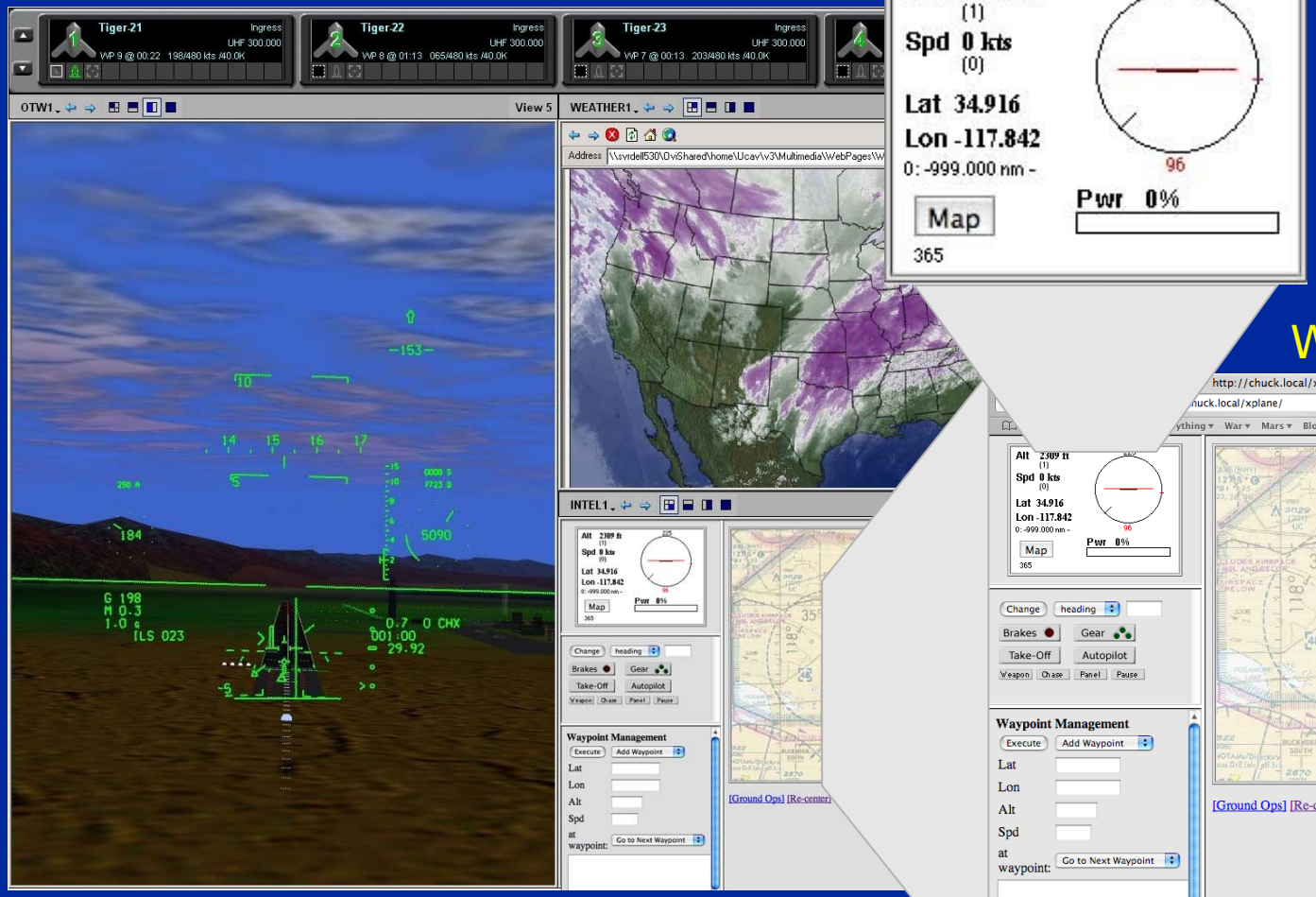
COS Heterogeneous HSI Integration

J-UCAS

Custom-built *COS* User Interface (UI) Container

COS-Generated Control



Web-based UI

Embedded UI Element

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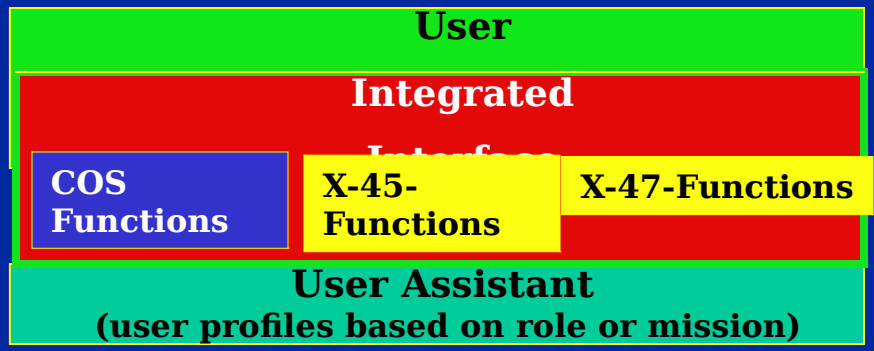
User Interface Migration Path

J-UCAS

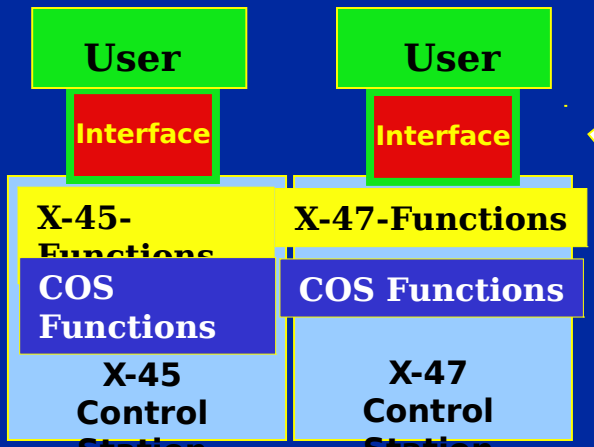
Future Vision

Integrated User Interface

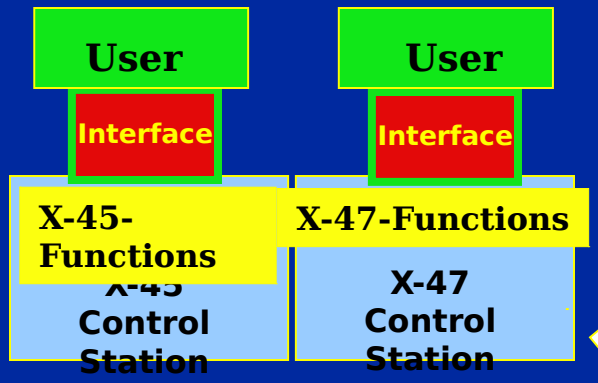


Operational Assessment

Common Functions



Now



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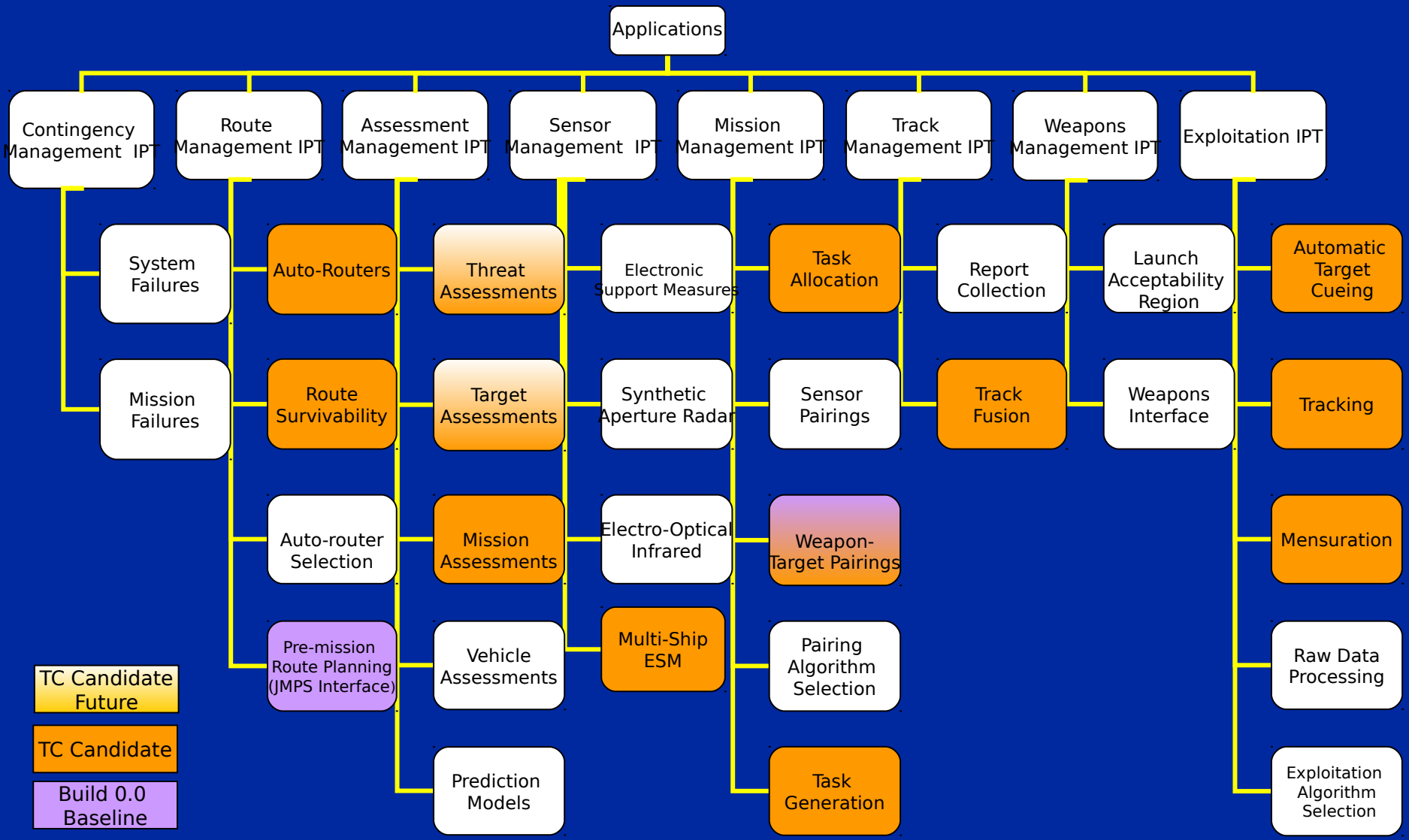
COS Applications (Detail)



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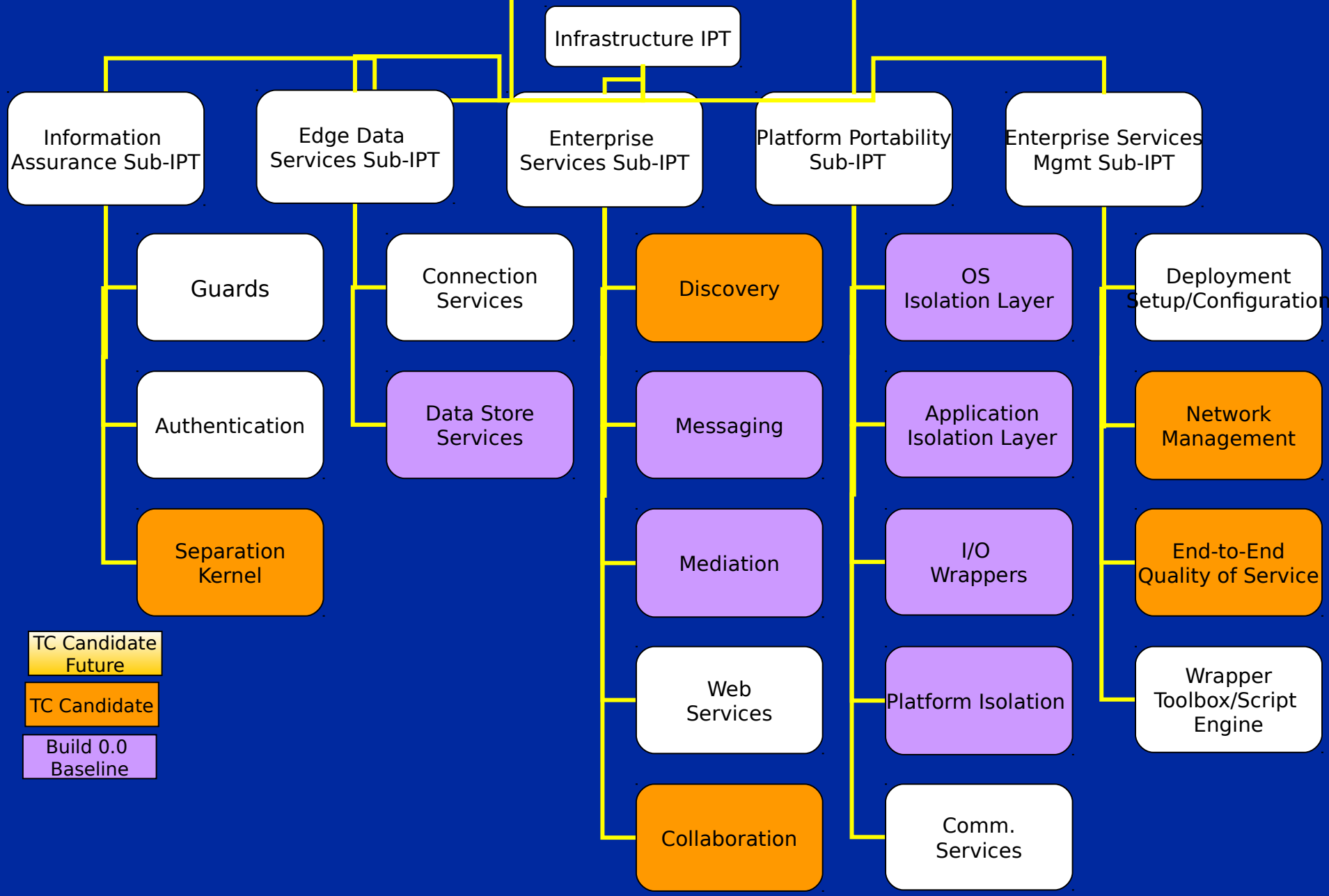
COS Infrastructure (Detail)



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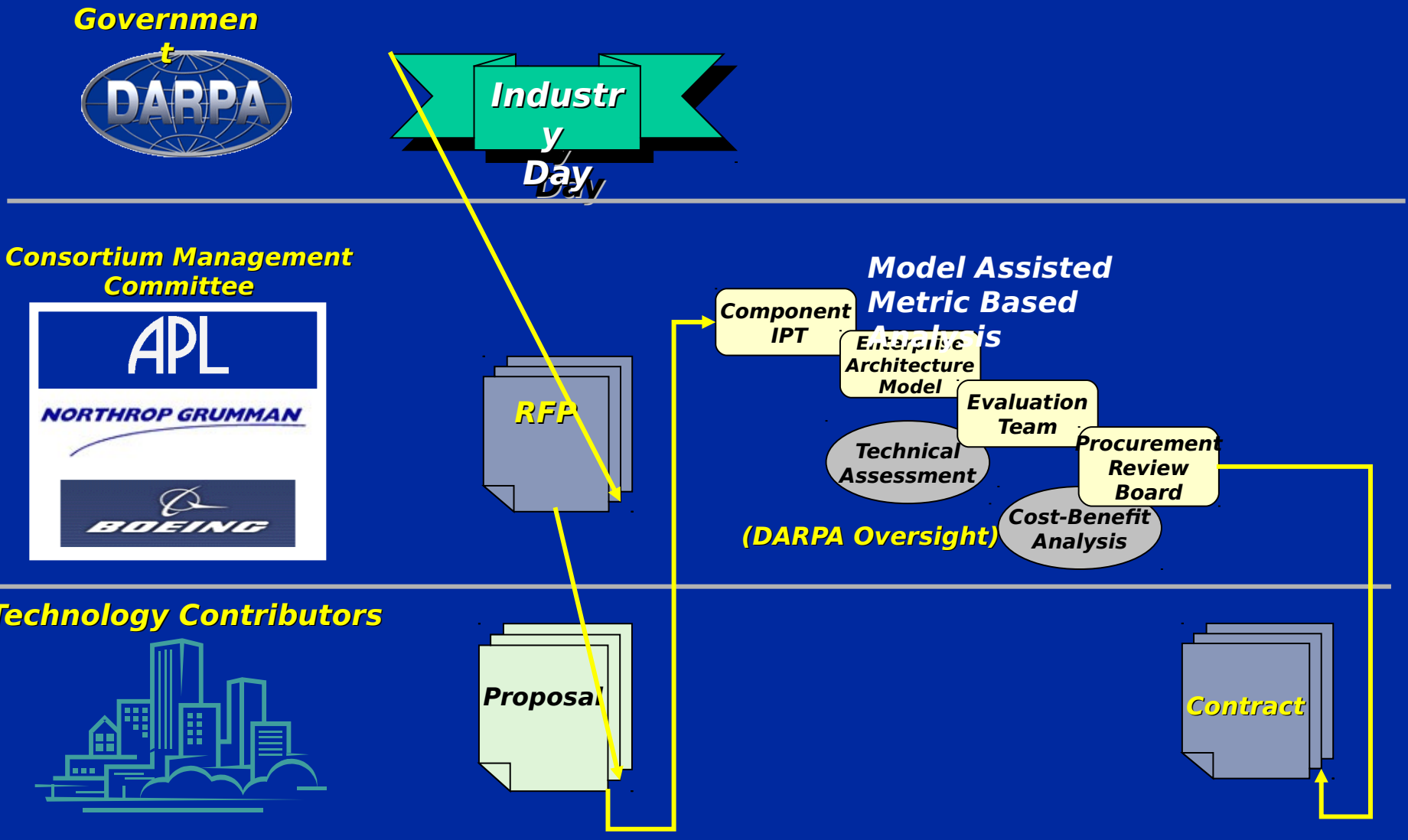
Notional Technology Contributor Selection Process



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TC Selection Process Features

- APL will coordinate process
- The Evaluation Team and the Procurement Review Board will include members from Boeing, NGC and APL
- Awards will be based on Selection Criteria to achieve best value for *COS*
- Selected TCs will be contributors, not consortium members
  - Contracting through APL
  - Technical I/F through IPTs

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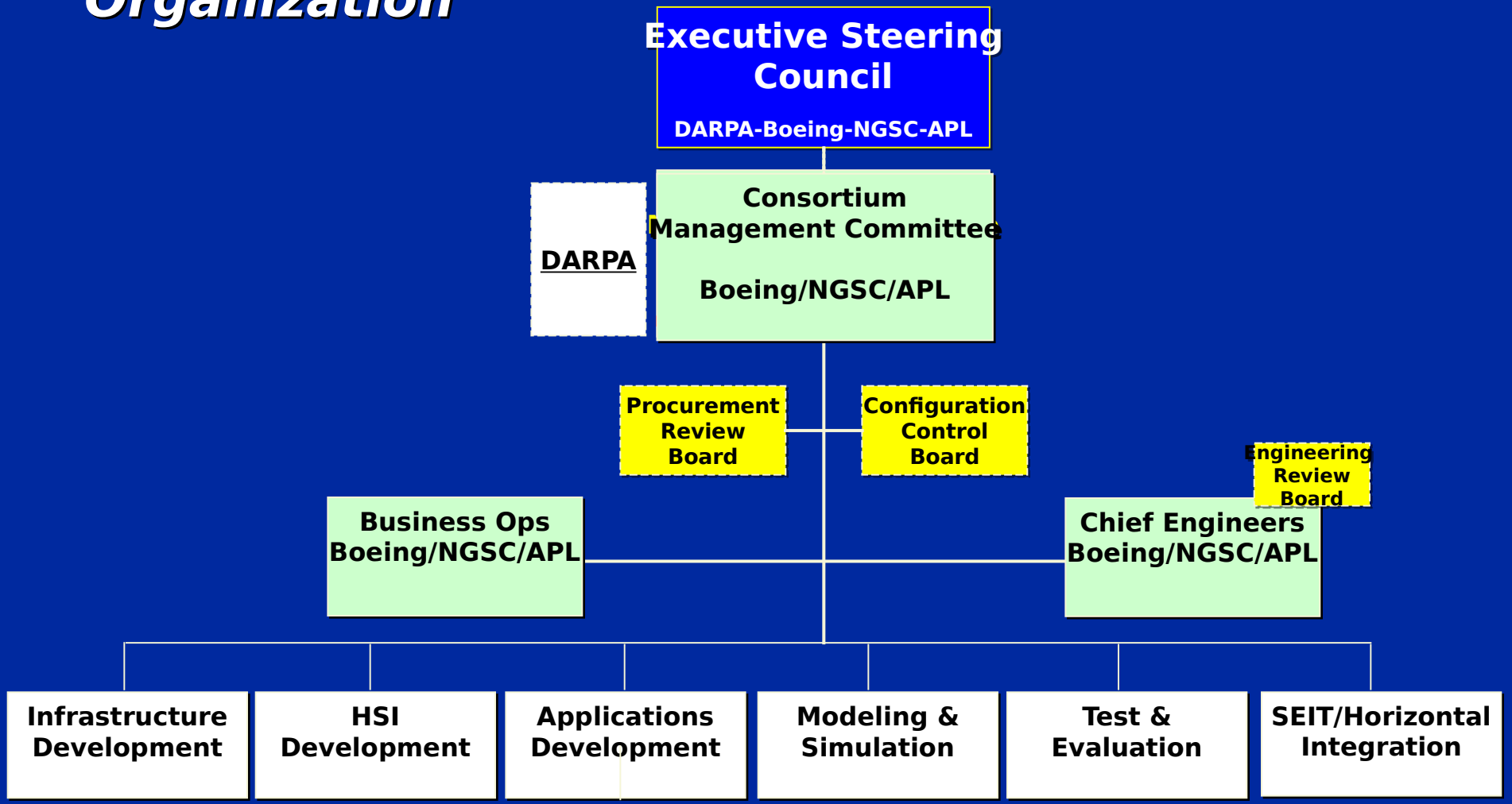
DRAFT COS Consortium Organization



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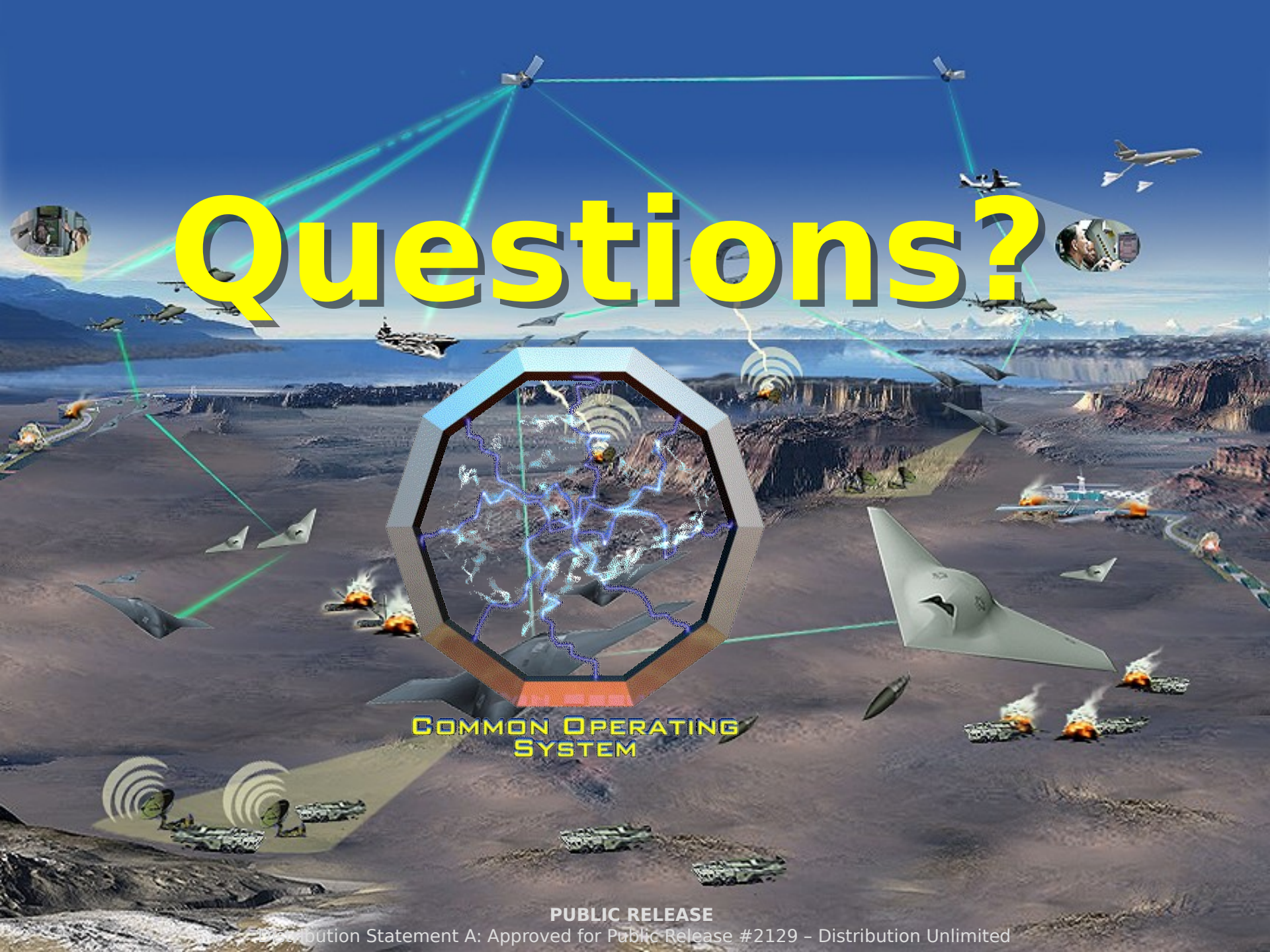

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